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NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER ATL--ETC F/G 1/5  
DULLES CONTROL TOWER CONSOLE DESIGN STUDY.(U)

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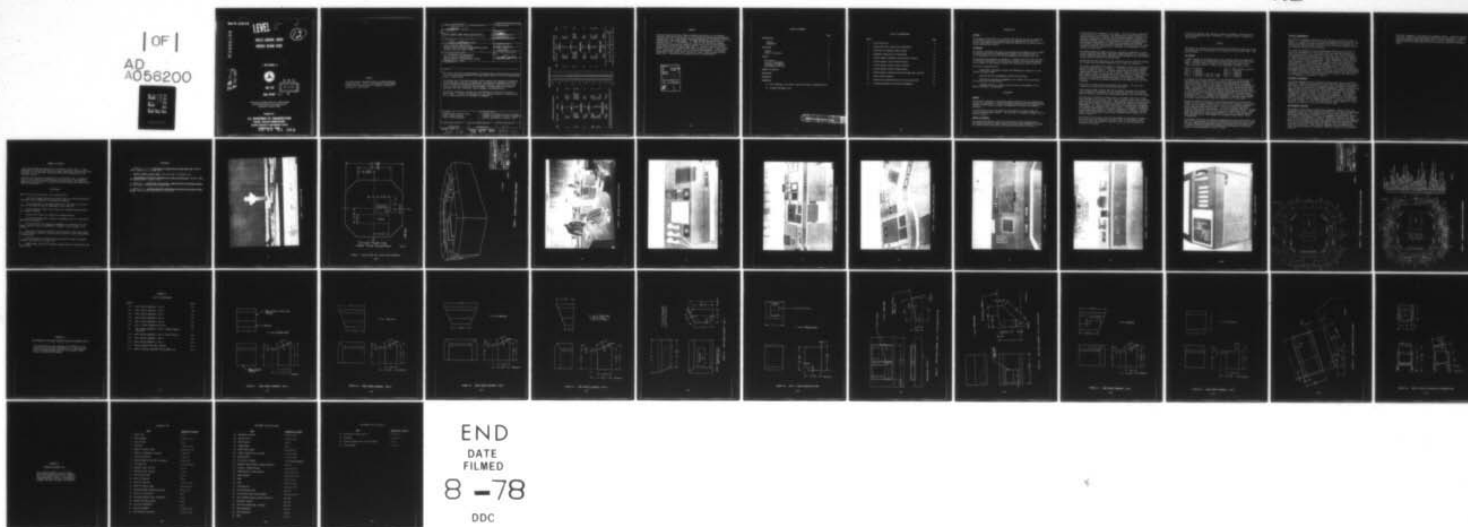
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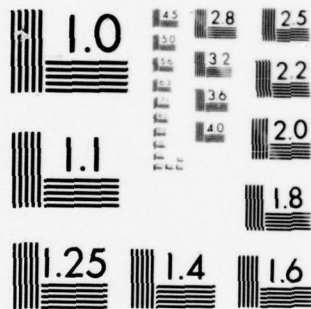
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**DULLES CONTROL TOWER  
CONSOLE DESIGN STUDY**

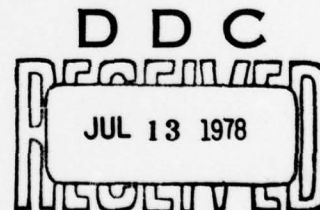
I. Roy Bradley, Jr.

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FINAL REPORT



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Prepared for

**U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION  
Systems Research & Development Service**

Washington, D.C. 20580

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Technical Report Documentation Page

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15. Abstract <p>This report describes the development and testing effort directed toward providing a plan for inservice improvements to the operational quarters of Dulles International Airport Control Tower.</p> <p>Through the use of full-scale mockups, console designs and equipment arrangements were established, modified, and appraised. Opinions and recommendations of Air Traffic Specialists and Airway Facility Sector personnel from Dulles Tower were used as a basis for determining the advantages or disadvantages of particular equipments and their locations, console designs, and modifications.</p> <p>The results constitute a proposal for refurbishing the operation's quarters of Dulles Tower. Included are drawings for a new console along with a detailed plan for an improved position and equipment arrangement.</p>					
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# METRIC CONVERSION FACTORS

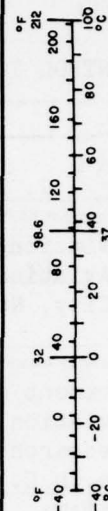
## Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	6.5	square centimeters	cm <sup>2</sup>
ft <sup>2</sup>	square feet	0.09	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.8	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.6	square kilometers	km <sup>2</sup>
	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft <sup>3</sup>	cubic feet	0.03	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

\* 1 in = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C13.10-286.

## Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	yards	yd
		0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	1.2	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.4	square miles	mi <sup>2</sup>
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	35	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.3	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



# PREFACE

The study described in this report represents one project of a continuing research effort under NPD No. SE-191, "ATC Operational Sustaining Engineering," subprogram 144-170, "Tower/TRACON Sustaining Engineering," sponsored by ARD-120, Richard Simon, subprogram manager. The NAFEC program manager was Felix F. Hierbaum, ANA-110. J. Roy Bradley, Jr., ANA-110, was the project manager. Construction innovations and technical inputs were provided by Donald Martin, Joseph Yugovich, and William Donaghy, ANA-110. Donald J. Juzwiak, ANA-522, prepared the pictorial rendition and other technical drawings. Robert Michael and L. Joseph Landi, ANA-521, were the project photographers. Lyle Hartman, operations officer Dulles tower, and John A. Curran, Chief Airways Facility Sector 832.1, functioned as the primary facility representatives.

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## INTRODUCTION

### PURPOSE.

The purpose of this report is to present data that can be used as guidelines by the Eastern Region of the Federal Aviation Administration (FAA) for a project involving refurbishing the operations quarters of the control tower at Dulles International Airport.

### BACKGROUND.

Two factors, advancing technology with miniaturized equipment and the vintage of Dulles tower, which is approaching 2 decades, have indicated that it is now appropriate to plan for the refurbishing of the Dulles tower cab.

This project was conducted in response to a request from the chief controller at Dulles for assistance from the National Aviation Facilities Experimental Center (NAFEC) in developing a proposal for updating the control tower cab.

The project objectives were:

1. Using mockup techniques, develop and demonstrate a design for a new console for Dulles tower.
2. Evaluate position arrangements using the new console.
3. Determine an equipment arrangement plan suitable for the positions of operation and the new console.
4. Recommend features to ensure that the overall environment will be modern, efficient, and desirable.

## DISCUSSION

### GENERAL.

This project represents a continuing research effort which was instigated to provide for increased air traffic controller capability and efficiency through improved console design, equipment arrangements, and modern environmental features.

The activities of this study were directed toward the control tower cab at Dulles International Airport. The cab shape is a modified octagonal and is shown in figure 1.

### METHOD OF APPROACH.

The project was guided by input and coordination among Systems Research and Development Service (SRDS), NAFEC, and Dulles tower personnel, including air traffic control specialists and Airway Facility Sector, AFS 832.1.

The activities were conducted in two phases. The first phase concentrated on development of a new console. The second phase involved evaluation of respective positions of operation and associated equipment locations. The above was accomplished in the Air Traffic Control Facility Configuration Laboratory at NAFEC, where full-scale mockups of console components along with designated equipments or facsimiles of equipments were provided. Periodically, Airways Facility Sector personnel and controllers from Dulles convened at NAFEC for demonstration, evaluation, and discussions of innovations for the project.

The console design was based on material contained in Department of Transportation (DOT)/FAA Order 6486.7 and report number FAA-RD-72-111 (reference 1). Certain dimensions and console components were modified so that the eventual console would be adaptable for Dulles tower.

Guiding factors and constraints to be considered were the stairwell opening, floor hatch area, and inside dimensions of the tower cab (figure 2).

The console was designed as a number of components or units to be installed around the perimeter of the tower cab. A pictorial of the basic perimeter console is shown in figure 3. Features tested during the study included console shelf heights of 30, 34, and 37 inches. Sections of the console were removed at the local and ground control positions to simulate locating BRITE radar displays on equipment carts at these locations. Removable shelves of various shapes were then affixed to the console at the radar positions to provide an unbroken continuity to the console shelf, and were evaluated.

Variations of a small island console were also tested. This unit was located on the west side of the stairwell enclosure.

After console design features had been evaluated, the mockup was equipped with representative equipments for the respective positions of operation. Figure 4 shows the project team installing equipment in the tower cab mockup.

The positions of operation, facing south in the tower, from left to right were: assistant local control, local control, ground control, mobile lounge, clearance delivery, and flight data. Participating subjects from Dulles tower again convened at NAFEC to discuss and appraise the position and equipment arrangement. As a result of these exercises, some changes were recommended. These changes are reflected later in the report. The equipment arrangement as originally demonstrated is presented in figures 5 through 9. The island console containing replicas of a mimic lighting panel, instrument landing system (ILS) monitor panel, and the spot frequency remote control unit is shown in figure 10.

The subject of the overall tower cab environment was discussed at length, and it was noted that because controllers "live" in facilities as well as work in them, the operation's quarters should be both functional and esthetically pleasing.

Criteria for improved light systems, acoustical treatment, and decor can be found in DOT/FAA Order 6480-7 (reference 2), Handbook 6000.16 (reference 3), and reference 1.

## RESULTS

The results are subjective and were obtained from evaluations conducted in the laboratory and final debriefings with the subjects and the project team. They are as follows:

### THE CONSOLE.

A console design was developed based on the standard console for eight-sided towers. Changes in the dimensions were made to adapt the console to Dulles tower. The final design consisted of 18 individual units plus a water fountain and sink (unit F). These units, identified in figure 11, are:

Unit A - 2 required	Unit F - Water fountain and sink
Unit B - 1 required	Unit G - 2 required
Unit C - 4 required	Unit H - 1 required
Unit D - 4 required, 2 left and 2 right	Unit I - 1 required
Unit E - 2 required, 1 left and 1 right	Unit J - 1 required

In addition to the above components, it was determined to provide space for four BRITE radar displays at two local control positions and two ground control positions. The plan was to mount the BRITE displays on equipment carts and to locate them in open spaces in the console at the designated positions. It was felt that this plan would satisfy both operational and maintenance requirements. In order to maintain continuity to the console shelf, it is intended to provide removable custom flight progress strip bays (unit G) at the local control positions and removable shelves at the ground control positions (figure 11). Drawings with dimensions of all units are contained in appendix A. Also in appendix A are drawings for portable flight progress strip bays (eight required) which are planned for use in the tower.

Particular features developed for the proposed console are: 34-inch shelf height, 20-inch depth of console units to provide for storage of oxygen masks in the cab, an increased shelf area for unit I to locate Electro-writers, and an increased shelf area for unit J to locate the flight data entry printout (FDEP) printer and keyboard. It is also planned to install a sliding track below the shelf of unit J for location of a spare FDEP printer. "Drop" tubes are proposed for installation between the tower cab and the Terminal Radar Approach Control Room (TRACON) for relaying flight progress strips on departures.

Participants noted that the preferred construction for the console should consist of a basic material covered with nonreflective Formica and that at least one spare equipment mounting panel should be provided for each console unit. It was felt that the equipment mounting panels and removable front panels should be quick-detachable for ease of access.



### POSITION ARRANGEMENTS.

The position arrangement developed for use with the new console is shown in figure 11. It was felt that this position arrangement would satisfy all operational requirements and should increase the efficiency of operations by providing for improved flight data flow in the cab as well as easier coordination between the positions of operation.

The runway configuration at Dulles establishes traffic flows for either a north or south operation. The proposed position arrangement locates the flight data position on the west side of the tower cab. Flight information for departing aircraft emanating at the flight data position can be passed in proper sequence either to the right or left depending on whether there is a north or south traffic configuration. Flight information on arriving aircraft emanating at the assistant local control position can similarly be disseminated in an orderly and proper sequence. The primary operation at Dulles is conducted with the controllers facing south. It was determined that during operations requiring the controllers to face north, the position arrangement should be a mirror image of that with the controllers facing south. The flight data position would remain stationary; however, the other positions of operation would move from the south side of the tower to the north side. This arrangement is illustrated in figure 11.

### EQUIPMENT ARRANGEMENT.

A proposed equipment list was furnished by Dulles tower and is contained in appendix B. NAFEC provided replicas of the respective equipments and mounted each item in the console mockup in accordance with a previously coordinated plan. During the evaluation of equipment arrangements, several variations were suggested and tried out in the lab. Eventually, an arrangement was agreed upon as being the most suitable for Dulles tower operation. This equipment arrangement is shown in figure 12 by position of operation. Two items of equipment not presently in use at Dulles were recommended for consideration. These are the mimic field lighting panel (reference 4) and an ILS monitoring unit that monitors five ILS systems (reference 5). Replicas of these units are shown in figure 10. The field lighting panel with a schematic of Dulles runways is located to the left of the ILS monitor panel.

### ENVIRONMENTAL FEATURES.

The subject of environmental features was addressed at length, and it was recommended that this area be given full attention at the time of refurbishing. Report No. FAA-RD-72-111 and Handbook 6000.16 could serve as guides for environmental improvement; however, it is suggested that additional research be conducted for innovations in lighting, acoustical treatment, and decor prior to final implementation of plans. A projection light fixture (Lightolier Model 7644) with framing, focusing, and dimming capabilities was demonstrated in the lab and was considered very effective as a unit for lighting the positions of operation. Other areas of lighting to be considered include floor lighting and general illumination, which are covered in the referenced material.

Acoustical treatment in ATC towers is an important factor. Acoustical ceiling tile with a light coat of water-based paint has proven successful. A tightly woven, high-quality commercial carpet used as a floor covering and on the stairwell walls has been effective both for acoustical properties and general decor.

## SUMMARY OF RESULTS

A new console design was developed for the Dulles control tower. It was determined that the proposed console is highly functional, provides additional floorspace in the tower cab, and improves the overall appearance of the operating quarters.

A position and equipment arrangement plan was developed that is compatible with the new console and should increase the efficiency of the operation. Suggestions were provided for updating the position lights and enhancing the tower cab environment.

## CONCLUSIONS

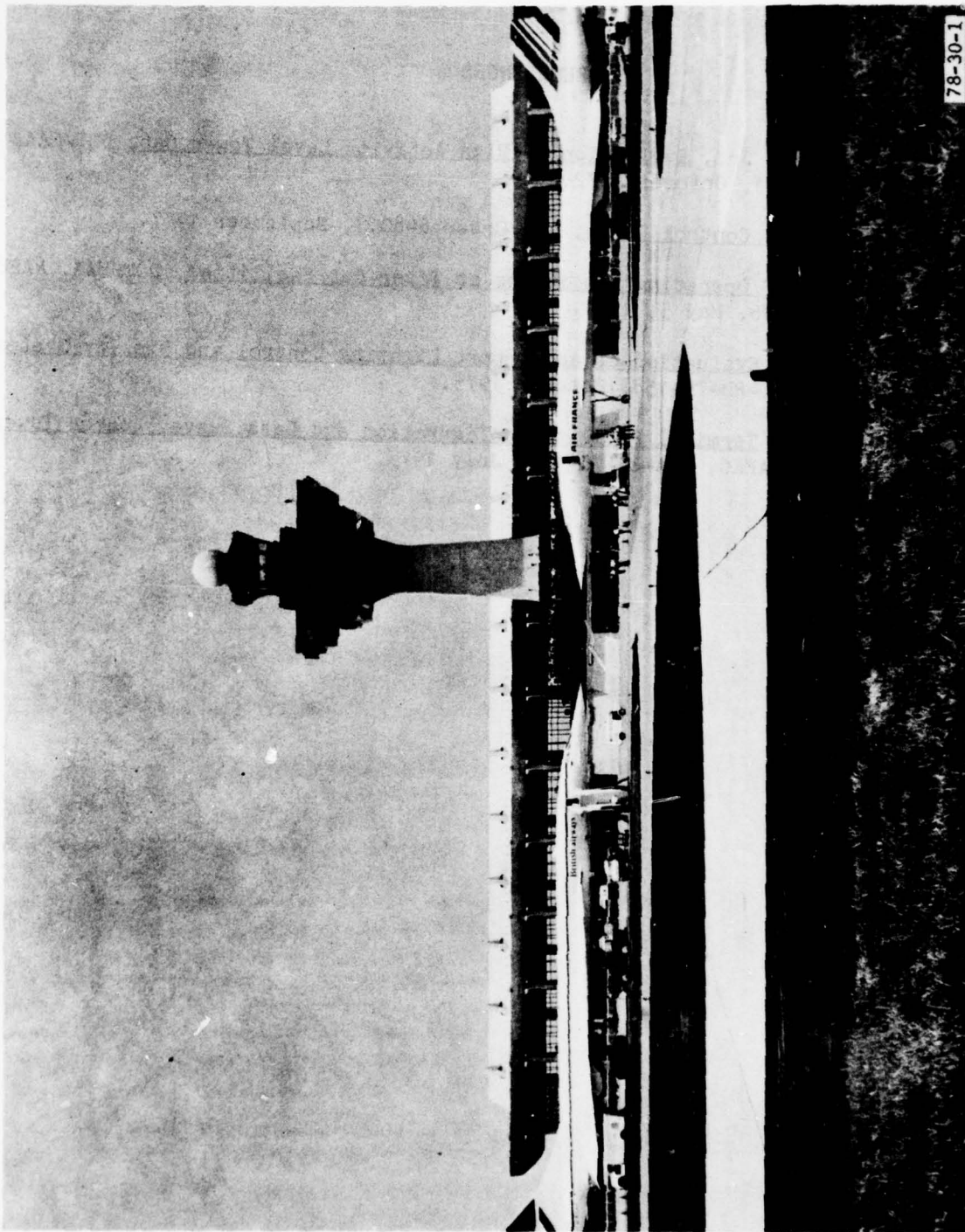
Based on the evaluation tests, it is concluded that:

1. The console design proposed for Dulles tower will satisfy operational requirements and accommodate the designated equipments.
2. The reduced size of the island console will contribute to the efficiency of the operation and the appearance of the tower cab.
3. Quick-detachable console front panels and equipment-mounting panels are desirable features.
4. Console units should be covered with nonglare Formica.
5. Locating the BRITE radar displays in equipment carts will facilitate maintenance requirements.
6. The new position and equipment arrangement is satisfactory for the present operation and will accommodate a proposed future increase in air traffic.
7. Positions of operation located on the north side of the tower, should be a mirror image of those on the south side in order to retain a similarity of coordination.
8. Attention should be directed toward new position lights, acoustical treatment, and decor for the tower cab.
9. ON/OFF dimmer switches for position lights should be located under the console shelf.

#### REFERENCES

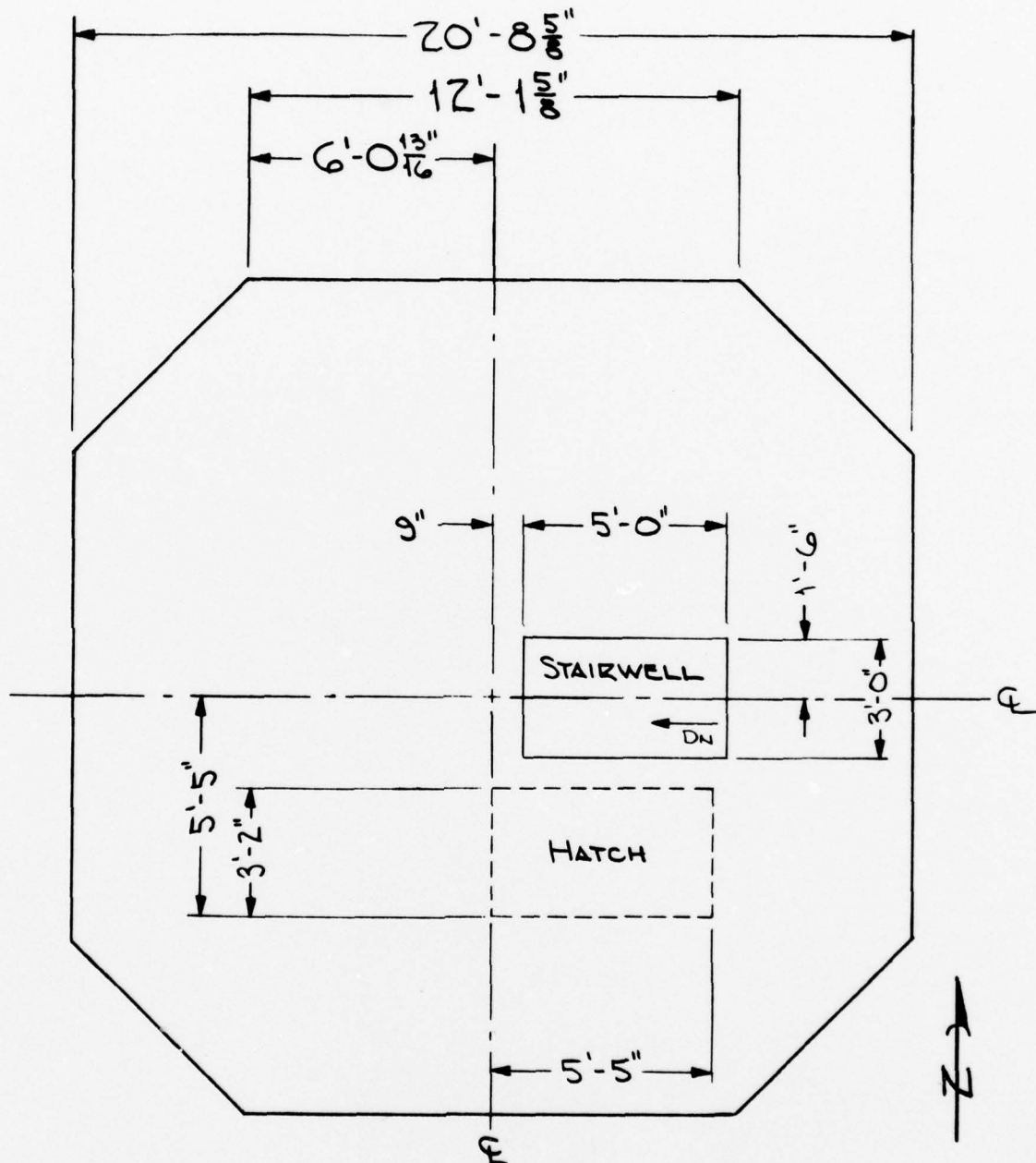
1. Bradley, J. R., Jr., Evaluation of High Activity Level Tower Cab, DOT/FAA, NAFEC, FAA-RD-72-111, October 1972.
2. Airport Traffic Control Tower, FAA Order 6480.7, September 1977.
3. Improvements of Operating Conditions at Tower Cab Facilities, DOT/FAA, NAFEC, FAA Handbook 6000.16, May 5, 1971.
4. Reamer, E. L., Evaluation of an Airport Lighting Control and Display System, DOT/FAA, NAFEC, FAA-RD-75-158, October 1975.
5. Martin, D. A., Terminal Facility Configuration and Data Survey Boston Tower/TRACON, DOT/FAA, NAFEC, FAA-RD-75-170, July 1975.





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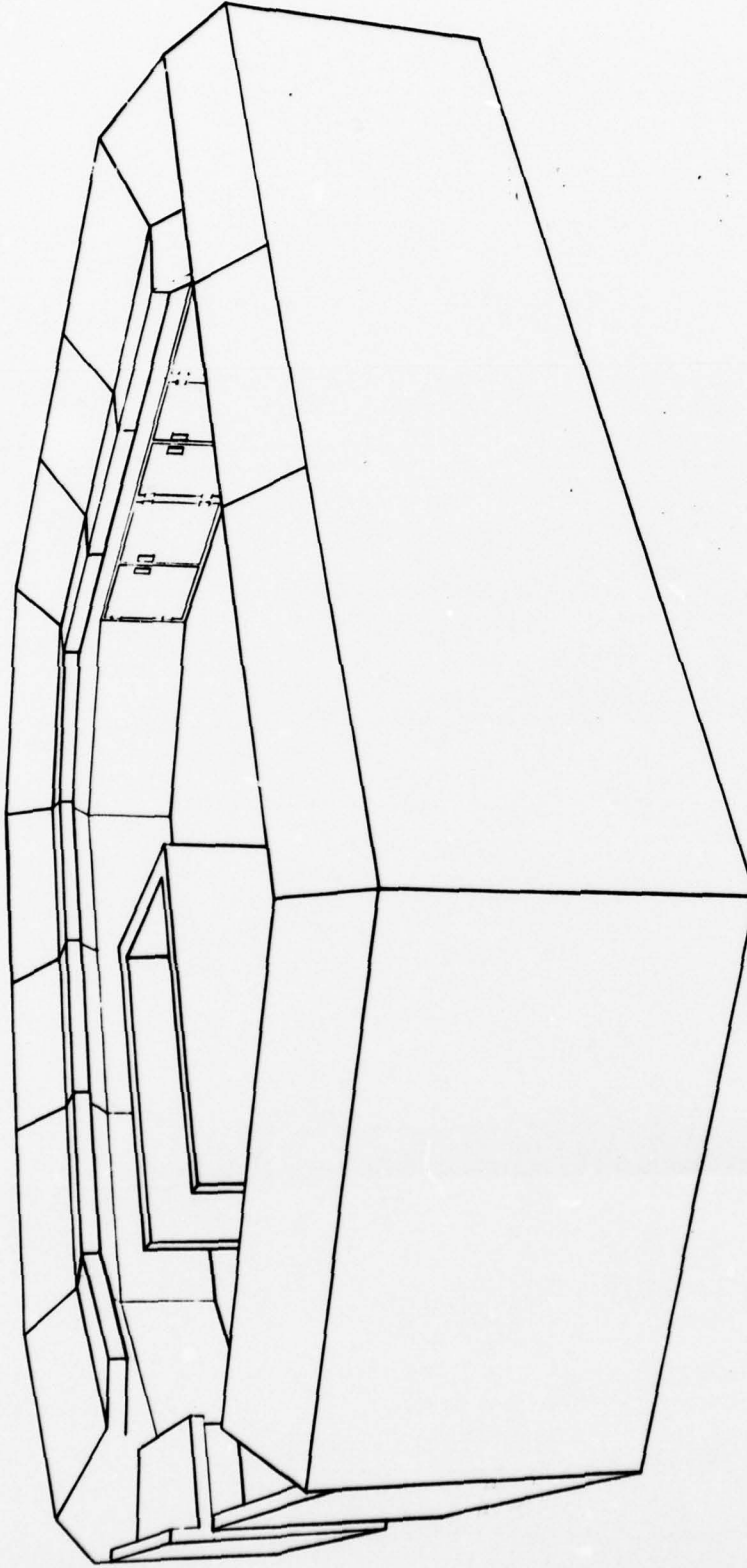
FIGURE 1. DULLES CONTROL TOWER



DULLES TOWER CAB  
INSIDE FLOOR DIMENSIONS

78-30-2

FIGURE 2. DULLES TOWER CAB, INSIDE FLOOR DIMENSIONS



No Scale

78-30-3

FEDERAL AVIATION ADMINISTRATION NATIONAL AVIATION FACILITIES DEVELOPMENT CENTER ATLANTA, GA.	
JULIUS ROBERTSON PICTORIAL PROPOSED CONSOLE DESIGN	
ANA-110	ANA-500
2-17-73	10-28-71

FIGURE 3. PICTORIAL OF PROPOSED CONSOLE DESIGN

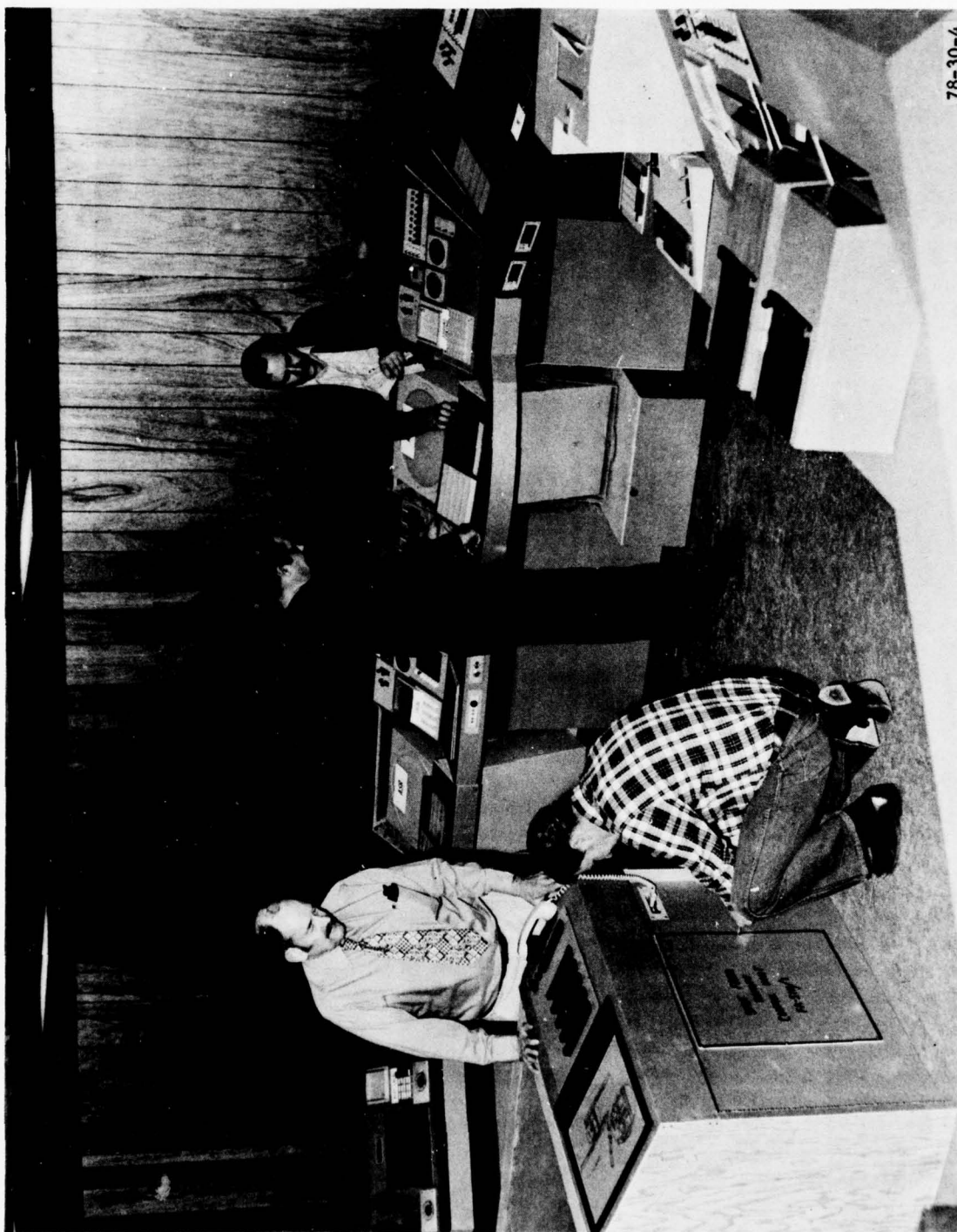


FIGURE 4. EQUIPMENT INSTALLATION IN THE MOCKUP



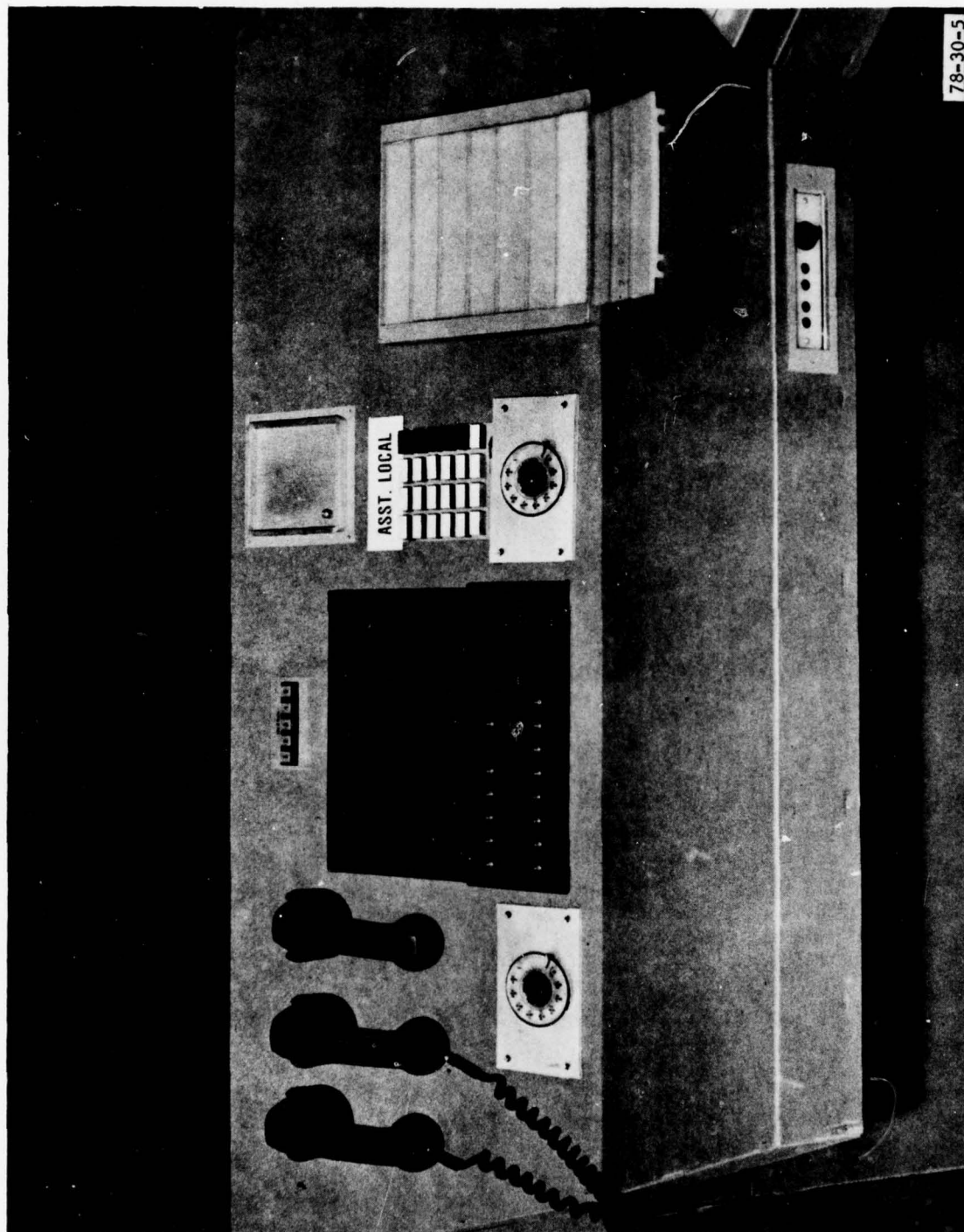


FIGURE 5. CONSOLE MOCKUP, ASSISTANT LOCAL CONTROL POSITION

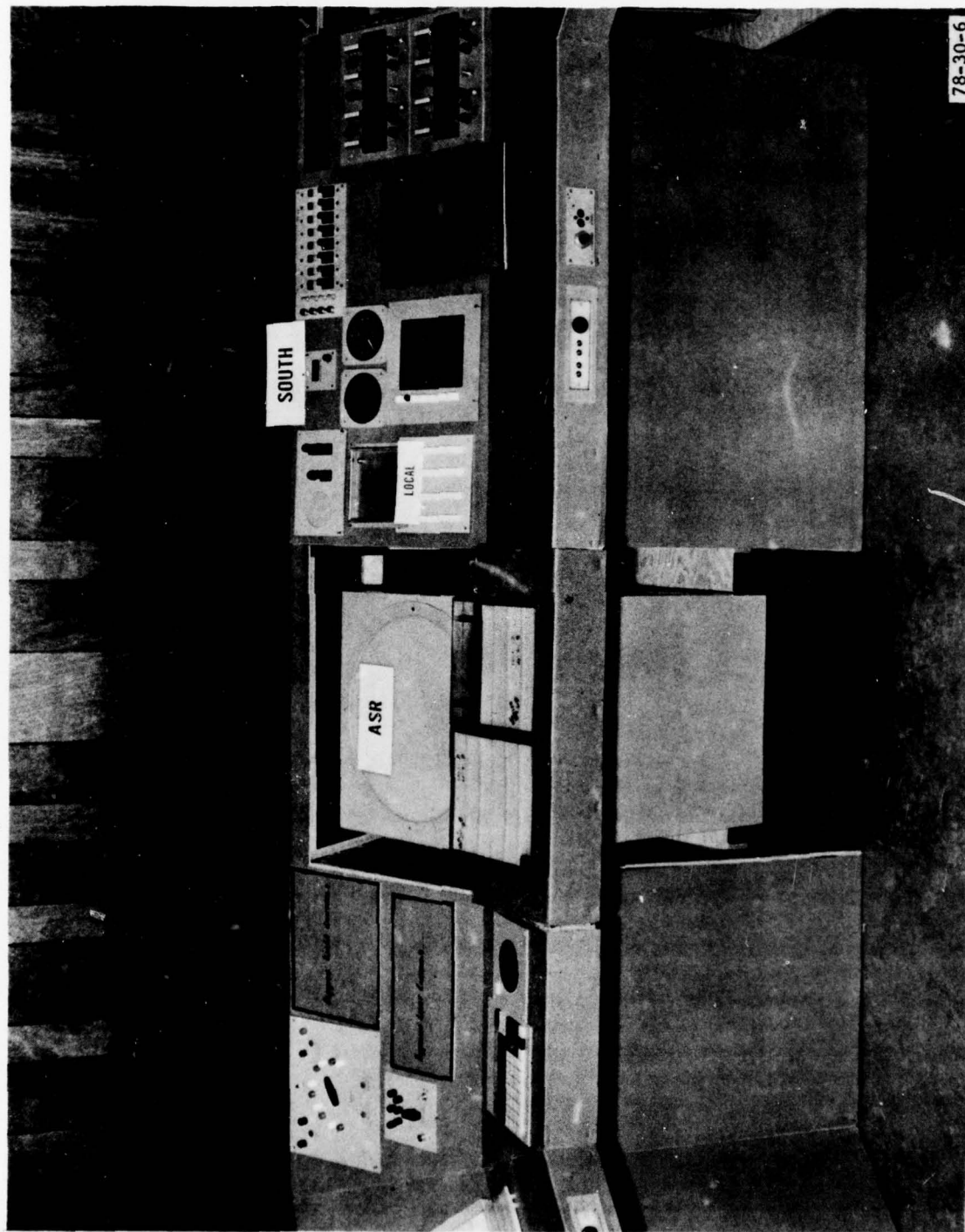


FIGURE 6. CONSOLE MOCKUP, LOCAL CONTROL POSITION

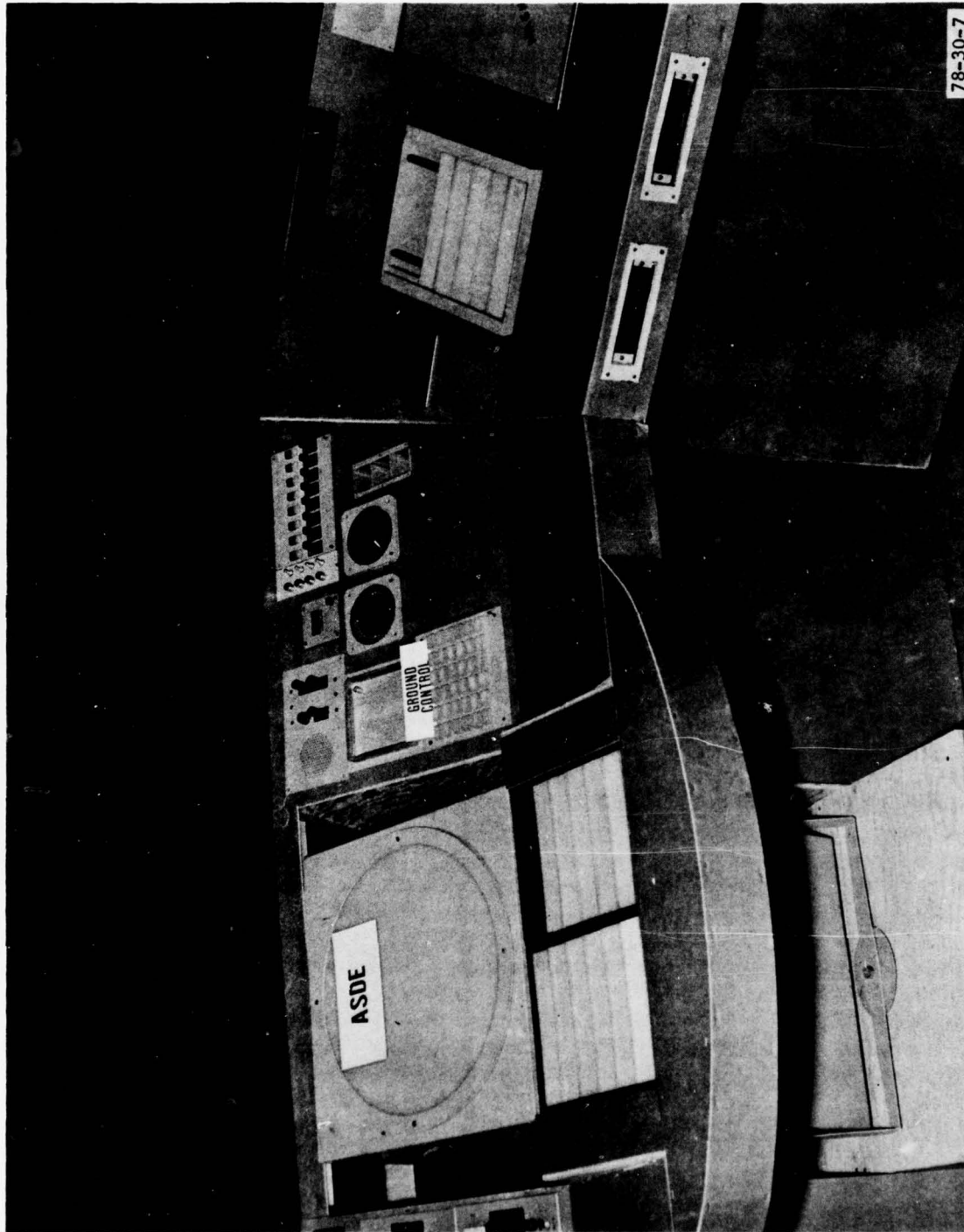


FIGURE 7. CONSOLE MOCKUP, GROUND CONTROL POSITION

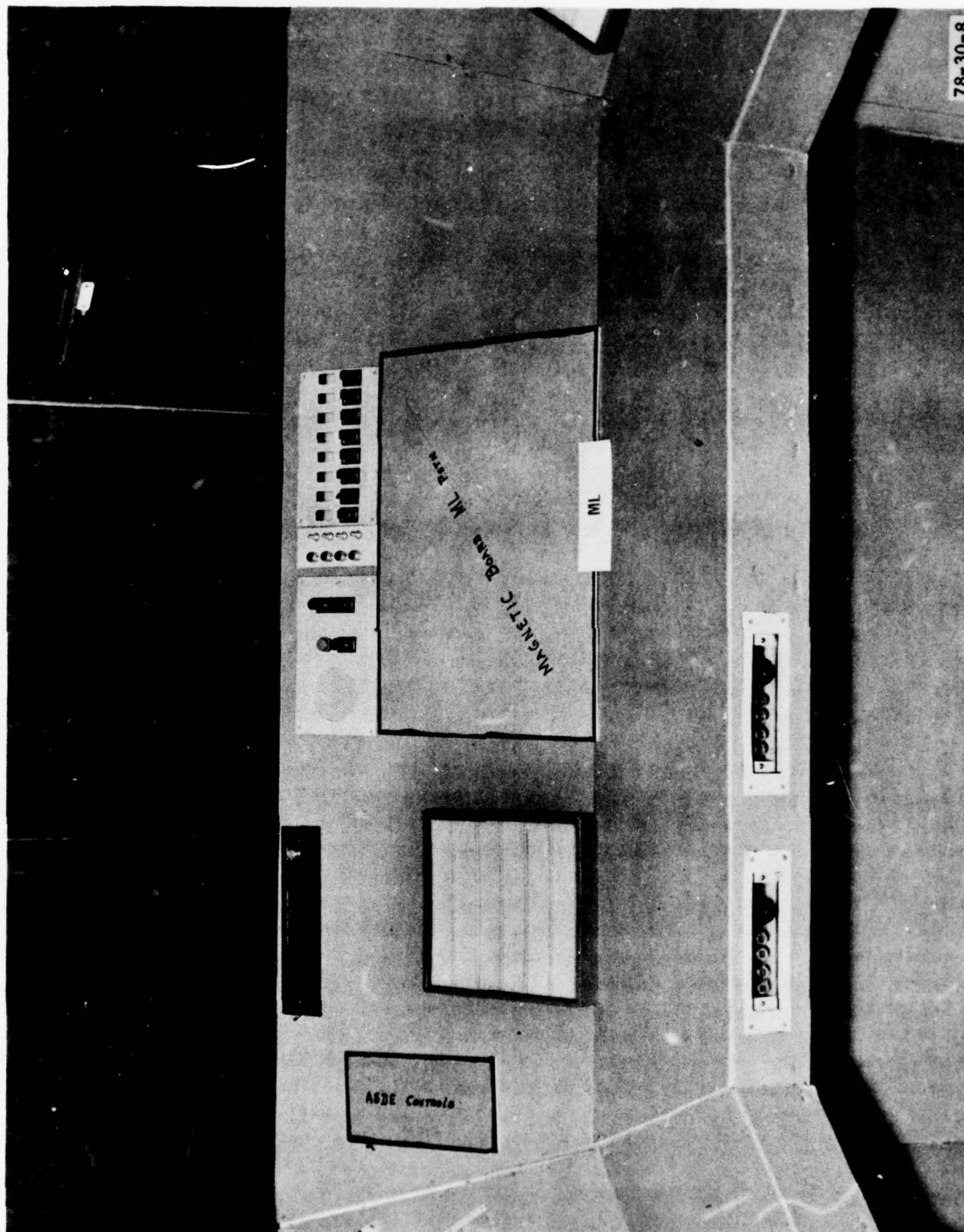


FIGURE 8. CONSOLE MOCKUP, MOBILE LOUNGE POSITION





FIGURE 9. CONSOLE MOCKUP, CLEARANCE DELIVERY/FLIGHT DATA POSITION

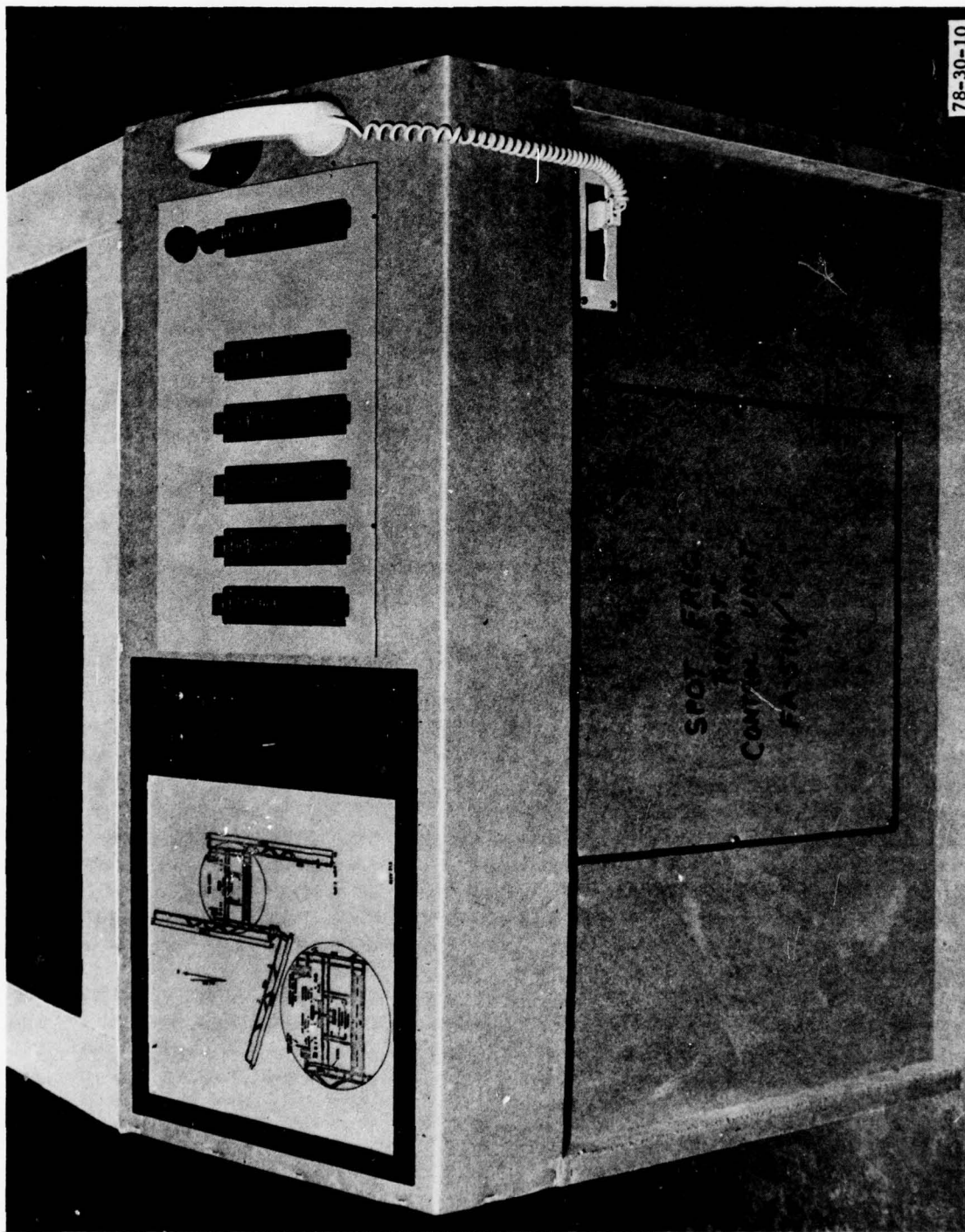


FIGURE 10. ISLAND CONSOLE MOCKUP



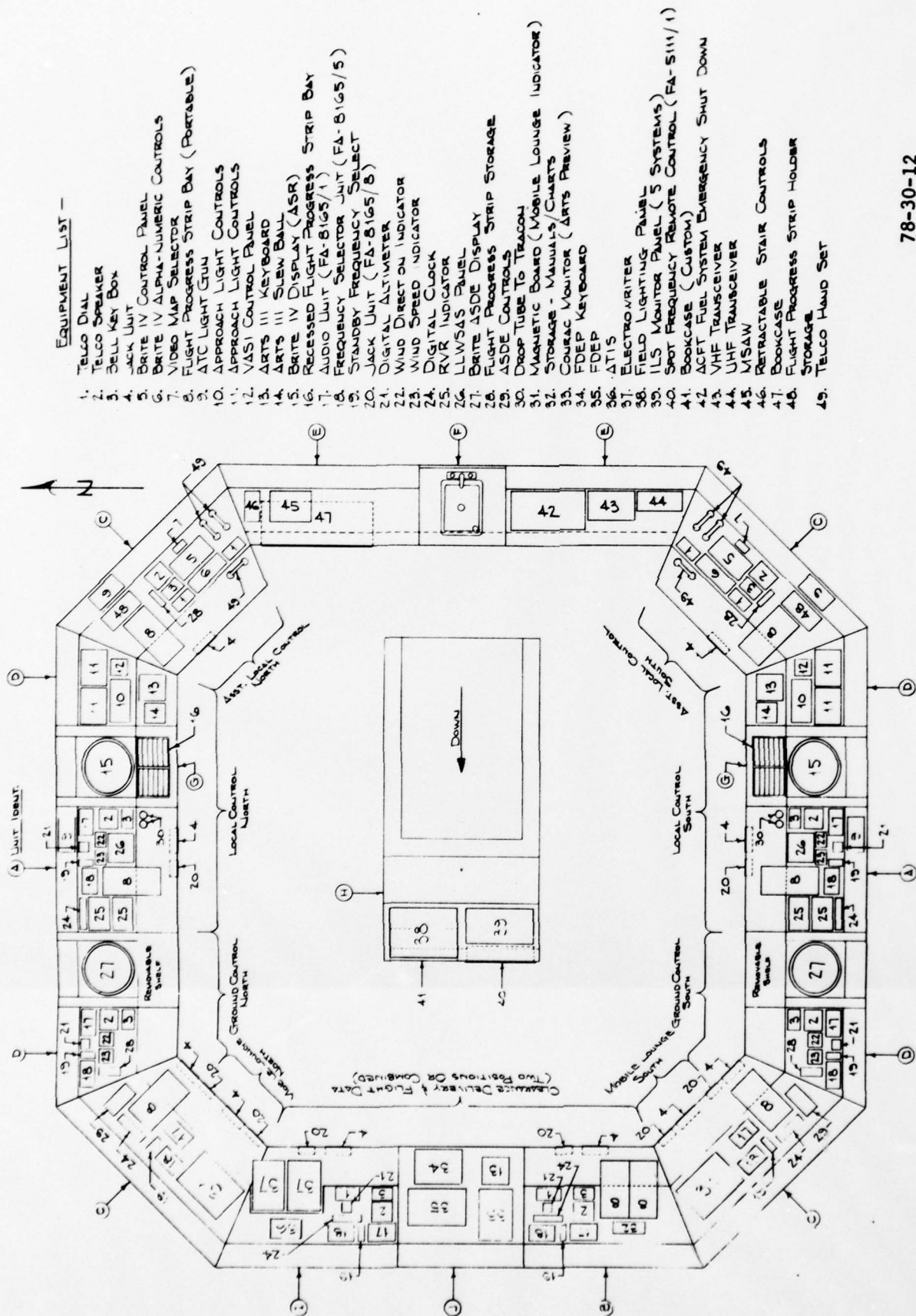


FIGURE 12. PROPOSED EQUIPMENT AND POSITION ARRANGEMENT



#### APPENDIX A

##### PLAN DRAWINGS OF THE TOWER CONSOLES AND OTHER CUSTOMIZED UNITS

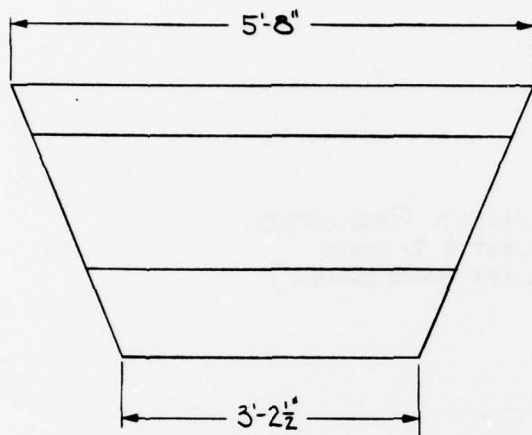
Contained herein are plan drawings with dimensions of the tower consoles and other customized units. These drawings are for planning purposes and are not intended as engineering or construction drawings.

APPENDIX A  
LIST OF ILLUSTRATIONS

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A-4	Tower Console Component - Unit D	A-4
A-5	Tower Console Component - Unit E	A-5
A-6	Unit F - Water Foundation and Sink	A-6
A-7	Tower Console Component - Unit G, Flight Progress Strip Bay	A-7
A-8	Tower Console Component - Unit H, Island Console	A-8
A-9	Tower Console Component - Unit I	A-9
A-10	Tower Console Component - Unit J	A-10
A-11	Flight Progress Strip Bay, Portable	A-11
A-12	BRITE IV Display (ASR/ASDE) and Equipment Cart	A-12







4 - UNITS REQUIRED

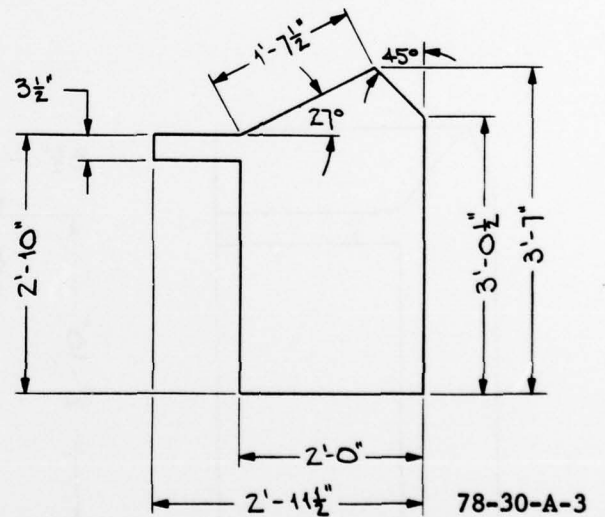
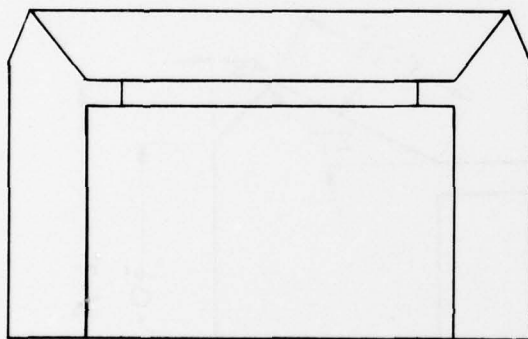
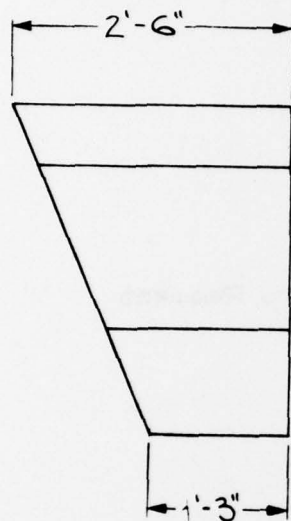


FIGURE A-3. TOWER CONSOLE COMPONENT - UNIT C



4 - UNITS REQUIRED  
2 - LEFT & 2 - RIGHT  
( LEFT HAND SHOWN )

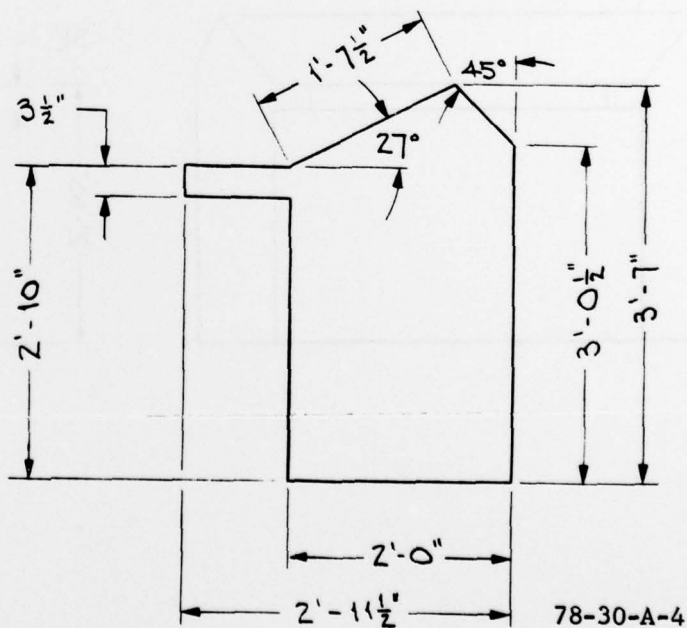
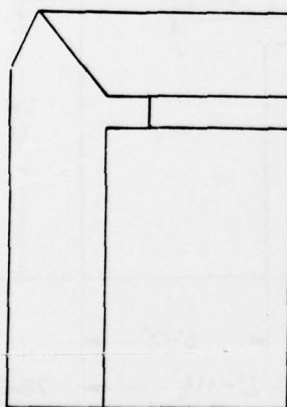
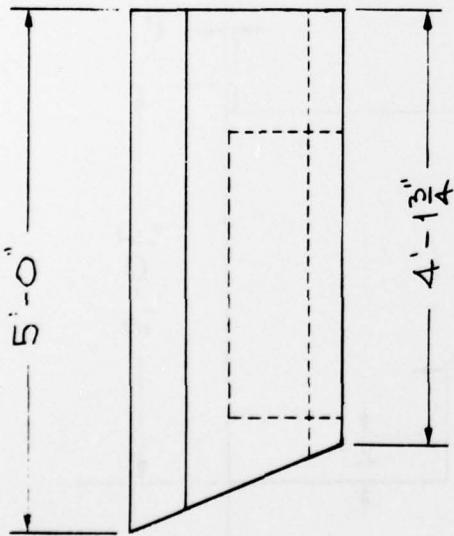
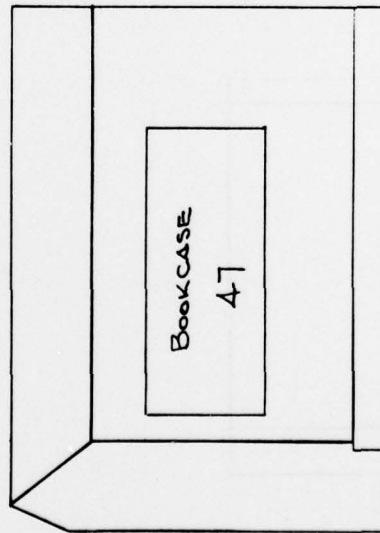


FIGURE A-4. TOWER CONSOLE COMPONENT - UNIT D





2-UNITS REQUIRED  
1-LEFT & 1-RIGHT  
(LEFT HAND SHOWN)



Note: BOOKCASE (#47)  
LEFT HAND ONLY

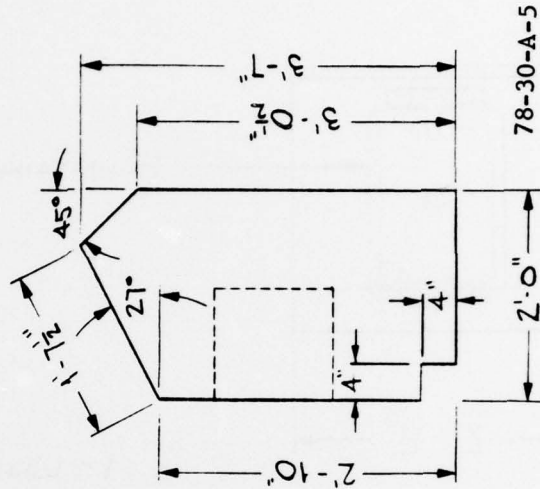


FIGURE A-5. TOWER CONSOLE COMPONENT - UNIT E

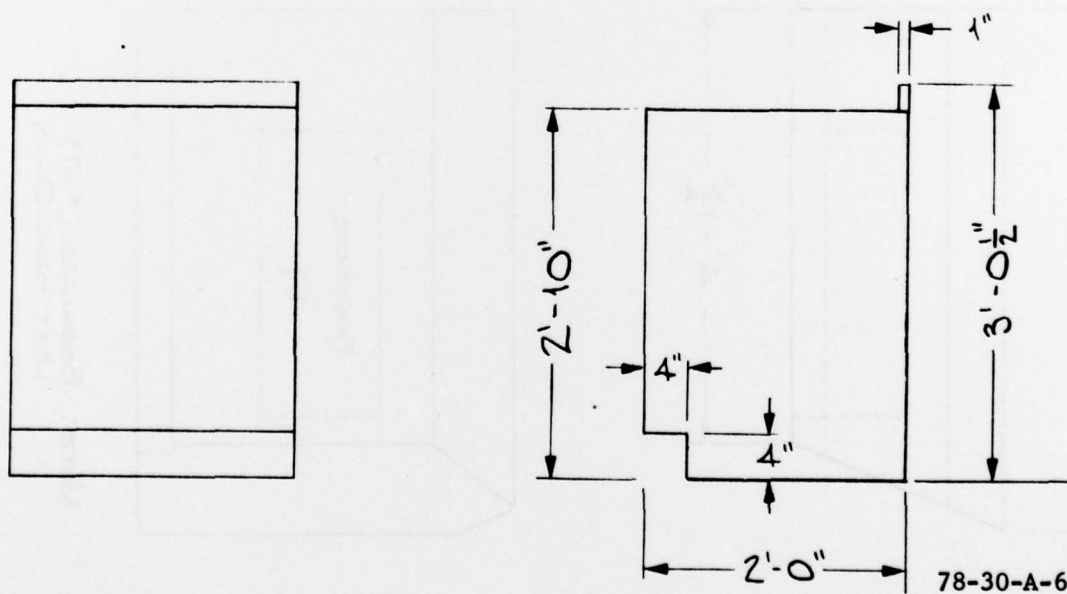
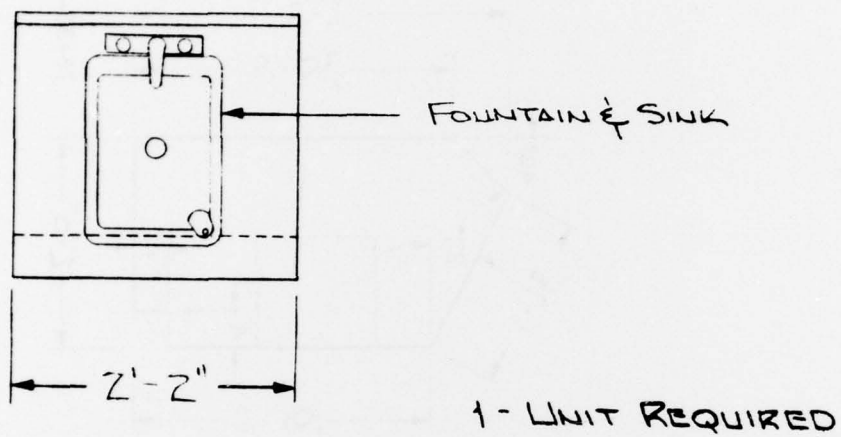


FIGURE A-6. UNIT F - WATER FOUNTAIN AND SINK



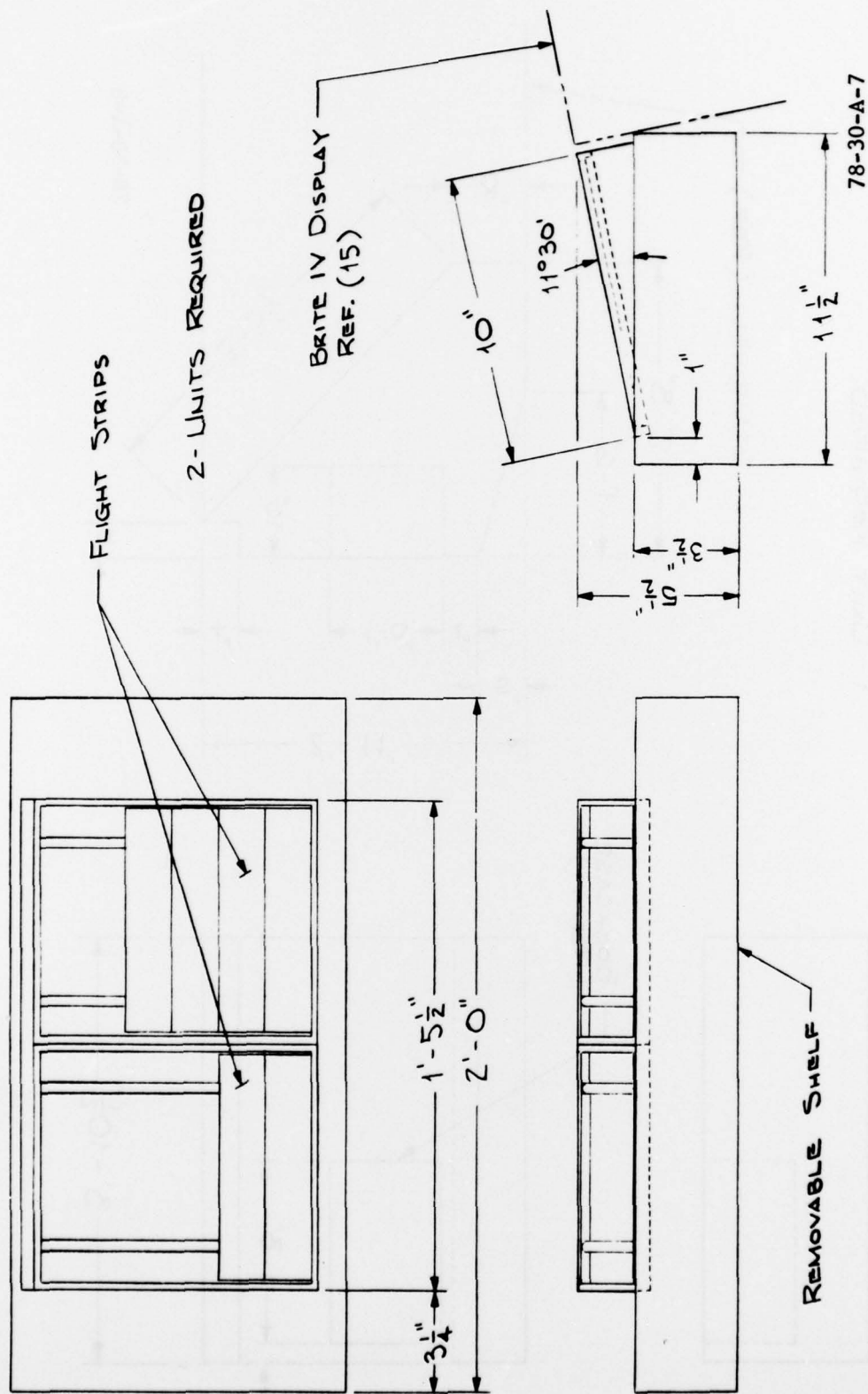
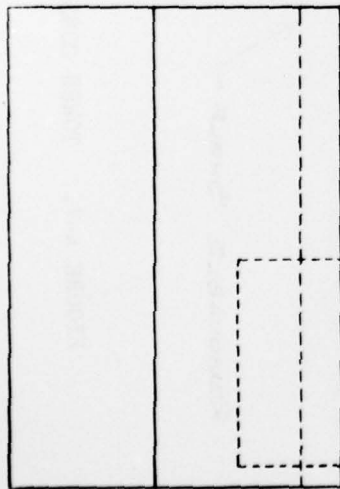
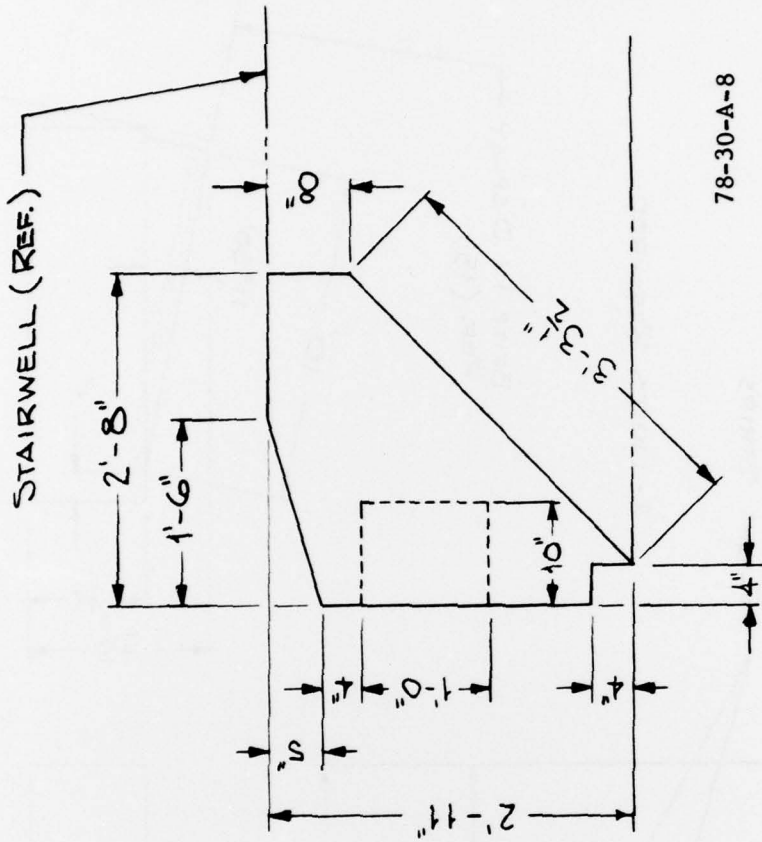


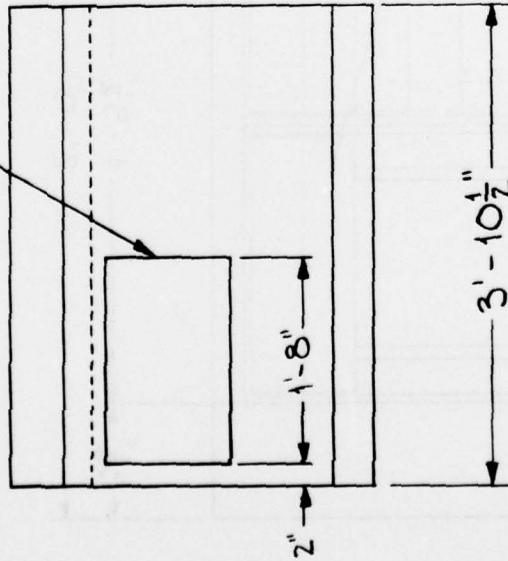
FIGURE A-7. TOWER CONSOLE COMPONENT - UNIT G, FLIGHT PROGRESS STRIP BAY



1 - UNIT REQUIRED

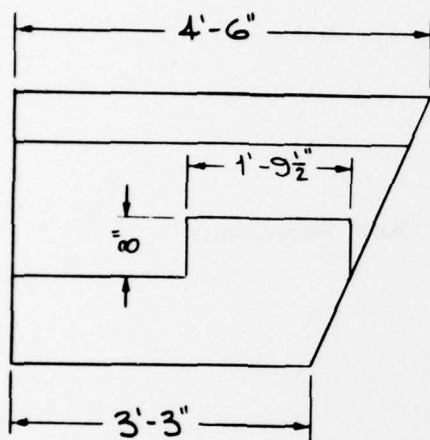


BOOKCASE  
(REF. 41)

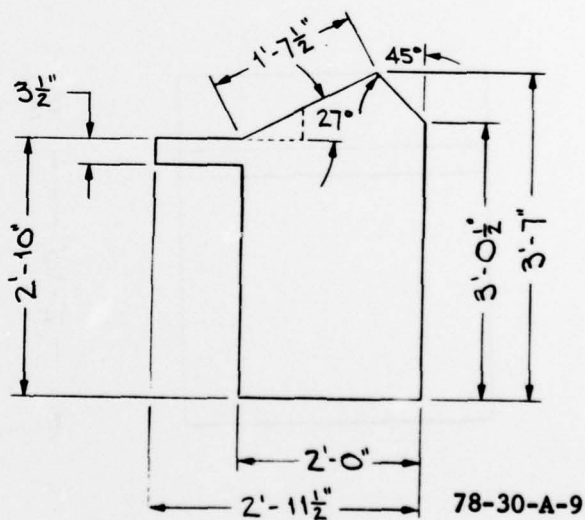
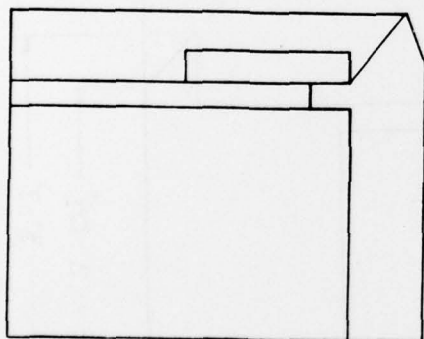


A-8

FIGURE A-8. TOWER CONSOLE COMPONENT - UNIT H, ISLAND CONSOLE



1- UNIT REQUIRED



78-30-A-9

FIGURE A-9. TOWER CONSOLE COMPONENT - UNIT I

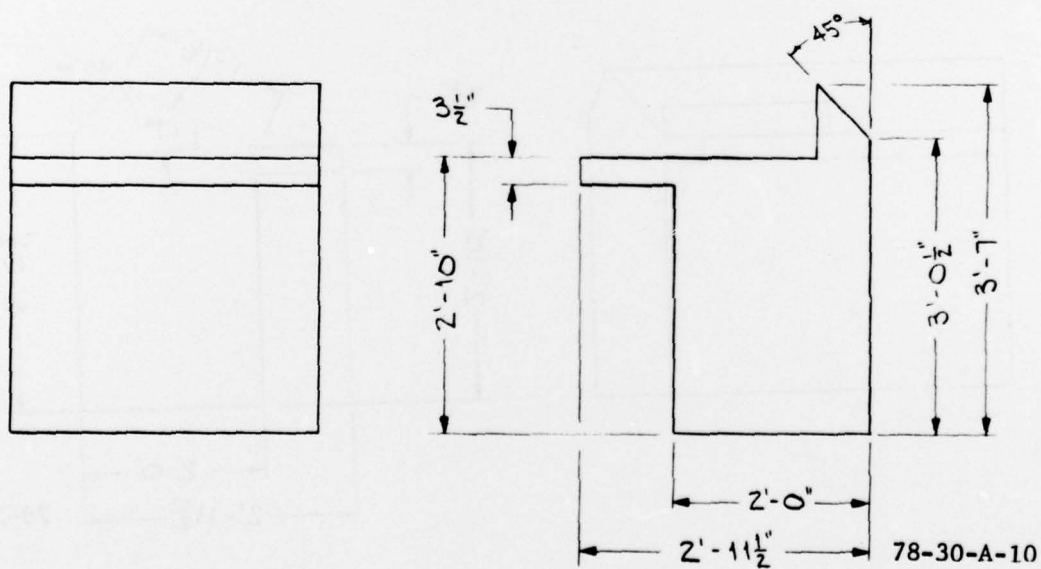
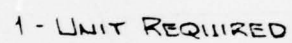


FIGURE A-10. TOWER CONSOLE COMPONENT - UNIT J

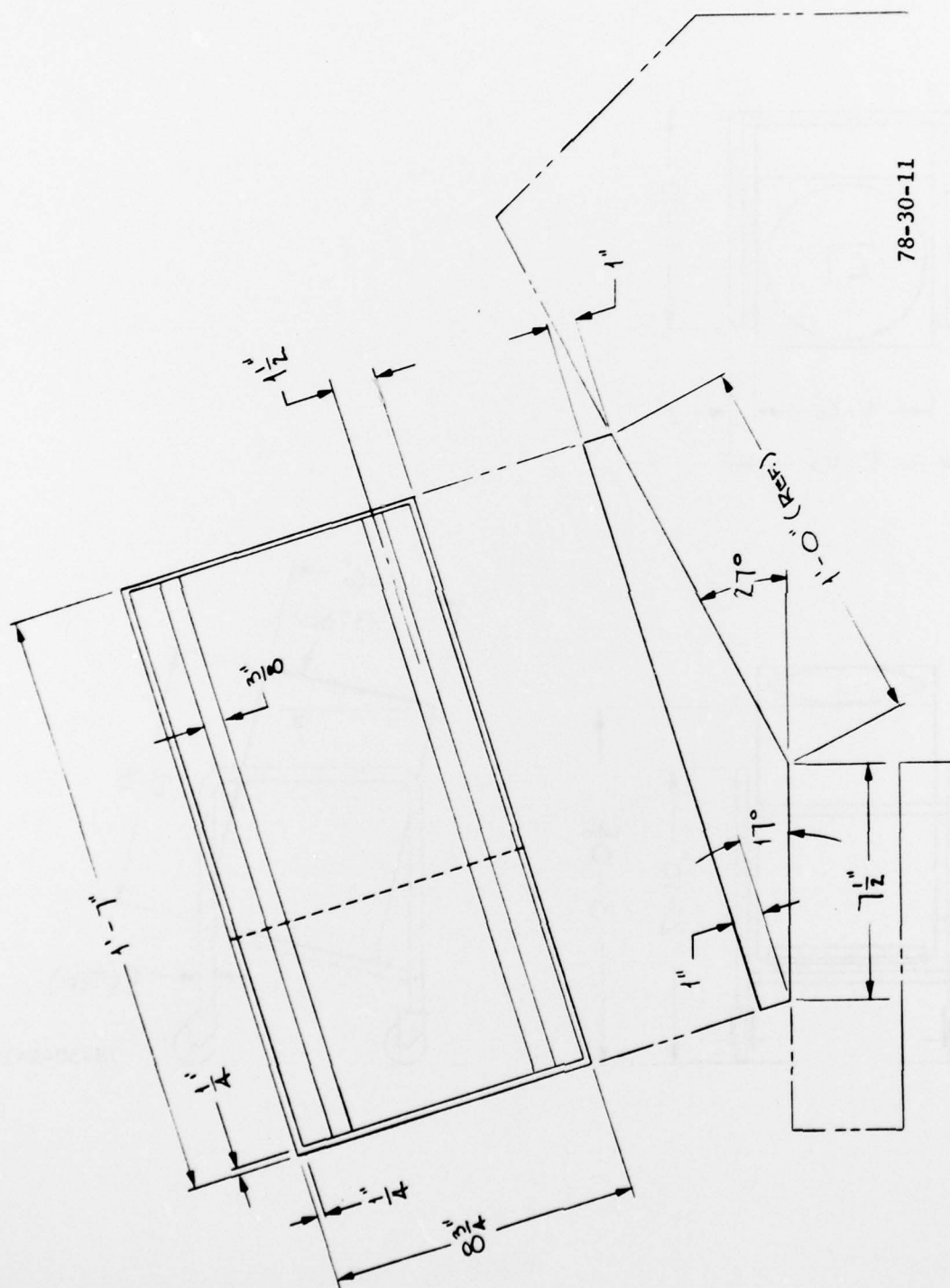


FIGURE A-11. FLIGHT PROGRESS STRIP BAY, PORTABLE



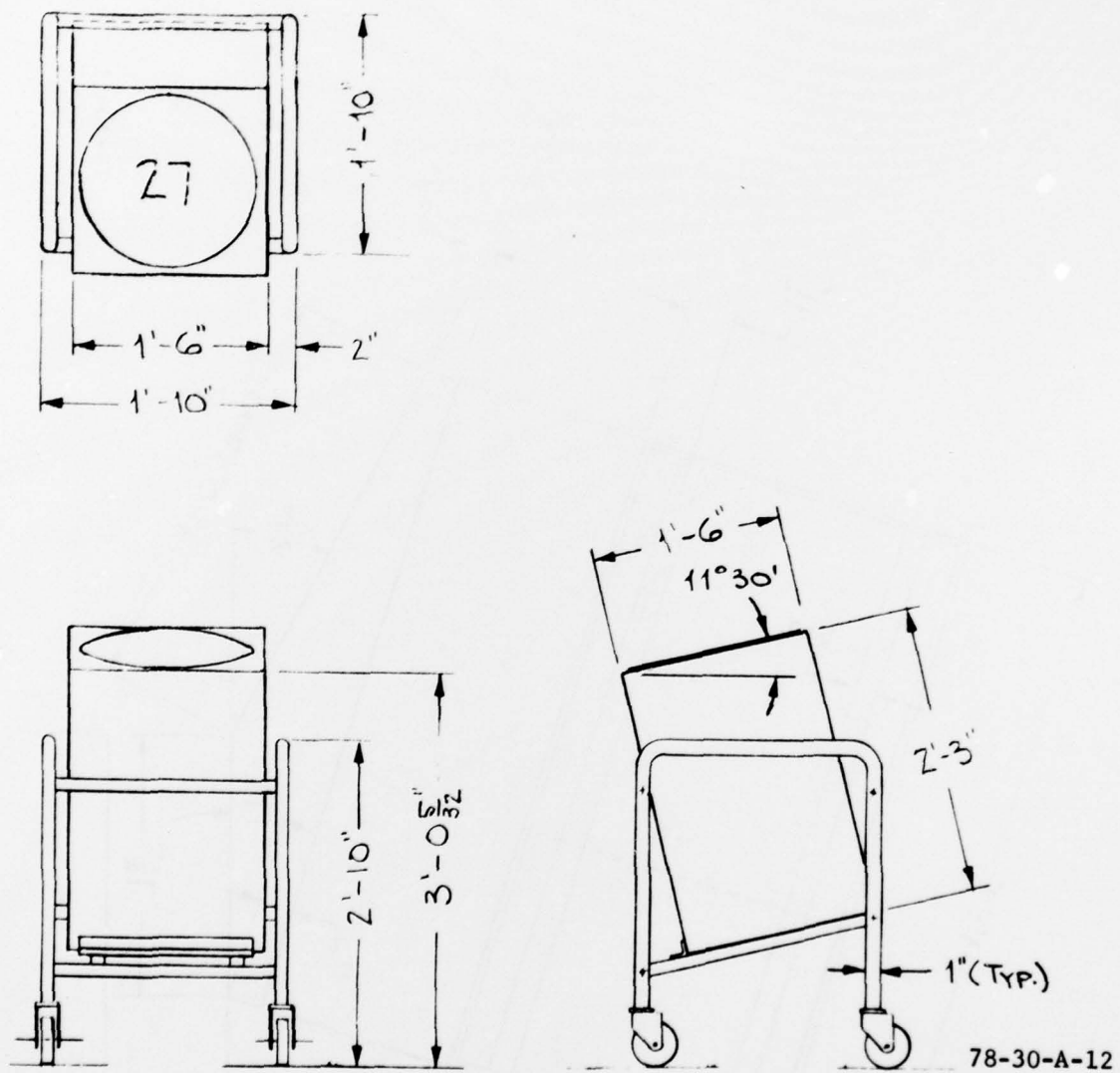


FIGURE A-12. BRITE IV DISPLAY (ASR/ASDE) AND EQUIPMENT CART

## APPENDIX B

### PROPOSED EQUIPMENT LIST

This appendix presents a list of equipments, with faceplate dimensions, proposed for Dulles Control Tower. It is subject to change depending on facility requirements, funding, and state-of-the-art developments.

# Equipment List

<u>Item</u>	<u>Dimensions (inches)</u>
1. TELCO Dial	7 x 4
2. TELCO Speaker	6 1/4 x 6 1/4
3. Bell Key Box	4 x 6
4. Jack Unit	7 1/2 x 2 1/8
5. BRITE IV Control Panel	12 5/8 x 7 1/4
6. BRITE IV Alphanumeric Controls	5 1/8 x 13
7. Video Map Selector	4 1/2 x 2
8. Flight Progress Strip Bay (Portable)	8 3/4 x 18
9. ATC Light Gun	6 1/2 x 10 1/2
10. Approach Light Controls	13 x 6
11. Approach Light Controls	11 x 9
12. VASI Control Panel	5 x 5
13. ARTS III Keyboard	8 x 8
14. ARTS III Slew Ball	6 1/4 x 6 1/4
15. BRITE IV Display (ASR)	18 x 18 x 27
16. Recessed Flight Progress Strip Bay	24 x 9 1/2
17. Audio Unit (FA-8165/1)	8 x 5
18. Frequency Selector Unit (FA-8165/5)	8 x 5
19. Standby Frequency Select	2 x 5
20. Jack Unit (FA-8165/8)	5 x 2
21. Digital Altimeter	3 1/8 x 3 1/8
22. Wind Direction Indicator	4 1/2 x 4 1/2

# EQUIPMENT LIST (Continued)

<u>Item</u>	<u>Dimensions (inches)</u>
23. Windspeed Indicator	4 1/2 x 4 1/2
24. Digital Clock	9 1/2 x 2 1/4
25. RVR Indicator	10 x 7
26. LLWSAS Panel	9 x 9
27. BRITE ASDE Display	18 x 18 x 27
28. Flight Progress Strip Storage	6 1/4 x 2 3/8
29. ASDE Controls	4 1/2 x 9 1/4
30. Drop Tube to TRACON	2 1/2 inside diameter
31. Magnetic Board (Mobile Lounge Indicator)	17 x 13
32. Storage - Manuals/Charts	9 1/2 x 3 1/2
33. CONRAC Monitor (ARTS Preview)	10 x 9 1/2 x 16
34. FDEP Keyboard	14 1/2 x 10 1/2
35. FDEP	17 x 11 x 12
36. ATIS	8 1/2 x 2 1/2
37. Electrowriter	9 1/2 x 7 x 15
38. Field Lighting Panel	20 x 16
39. ILS Monitor Panel (five systems)	19 1/4 x 12 1/4
40. Spot Frequency Remote Control FA-5111/1	20 x 20
41. Bookcase (custom)	15 x 21
42. ACFT Fuel System Emer. Shutdown	22 x 12
43. VHF Transceiver	14 x 9
44. UHF Transceiver	14 x 6
45. MSAW	12 x 9

EQUIPMENT LIST (Continued)

<u>Item</u>	<u>Dimensions (inches)</u>
46. Retractable Stair Controls	4 1/2 x 9
47. Bookcase	33 x 15 1/2
48. Flight Progress Strip Holder Storage	12 x 6
49. TELCO Handset	2 1/2 x 9